HYDROECOLOGY OF THE VEGETATION OF SANDY FOREST-STEPPE CHARACTER IN THE EMLÉKERDŐ AT ÁSOTTHALOM

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Abstract

One of the most intact areas of the ancient land unit of sandy forest-steppe character in the southern part of the region between the Danube and the Tisza is the conservation area of Emlékerdő at Ásotthalom about 30 km west of Szeged. This area has even been exempted from grazing. It was placed under protection many decades ago. Consequently, its plant communities land themselves particularly well for performing hydroecological investigations.

1. In the open steppe grass stand of *Festucetum vaginatae* on the humus-poor and quick sand hills and ridges, the subassociation of Stipa borysthenica dominates today. Its character species belong to the components 2 and 3 of steno-xerophytes.

2. In the spaces among the drying sand-hills of humus sandy surface soil, three sub-associations of *Festuco rupicolae-Salicetum rosmarinifoliae* can be differentiated. The species of their closed grass stands belong to steno-xerophyte 3 and asteno-xerophyte 1 categories on the basis of their contributions to coverage.

3. The differentiation of the subassociations of *Festuco (Querco)-Populetum albae* on humus sandy surface soil with buried brown forest soil seems to be related to the water and nutrient supply of the humus layer near the surface.

The regulation of internal waters resulted in the gradual sinking of the underground water level. Today the white and grey poplar stands are no more able to regenerate and are doomed to slow extinction. It is evident that the saving of the protected area is a very important task.

Introduction

The nature conservation area called Emlékerdő at Ásotthalom is one of the oldest protected areas in the southern part of the Great Hungarian Plain between the Danube and the Tisza. This ancient sandy forest-steppe relict (KISS 1915) left untouched for about a century and exempted even from grazing proved to be very suitable for the biocenotical and ecological investigation of the fauna (CSIZMAZIA 1979) and flora (BODROGKÖZY 1957) of the sandy forest-steppe of the Plain. A report on the composition, soil ecological conditions of the grass stands and poplar forests covering its sand-hills and the spaces between the hillocks was published 25 years ago ( ). In this paper the results of investigations performed earlier were also summarized. The aim of the present study was to explore the hydroecological properties of the phytocenoses in this protected area by the application of improved methods and register the changes which have taken place in the last ten years.

BABOS's work (1955) deals with the formation of the sandy forest-steppe in the region between the Danube and the Tisza and the forest stands there. The diversification of the relief in this area is due to the fact that the Danube had retreated from east to the west in geological times and the great mass of fluviatile sand it left behind was capriciously rearranged by the wind. The underground water table located once at a higher level resulted in the formation of bogs in the spaces between the sand-hills. This caused the sharp differentiation of the vegetation on the sand-hills from that on the wind-formed ridges. For the favourable water supply, the ancient forest stands of the sandy forest-steppe were made up of gallery forests of *Convallario-Quercetum roboris* and *Festuco-Quercetum roboris*. The unfavourable environmental effects produced partly by bogs characterizable by helophytes and partly by sand ridges covered with the open stands of xerophytes of sandy steppe, prevented the developing of continuous forest stands.

These ancient oak-forests have disappeared not only from the environs of Szeged, but are also very seldom found in the Great Plain. The becoming more arid of the climate, and the intensified regulation of internal waters during the last century have caused the lowering of the underground water level. The perished oak stands and those ones which fell victim to the increasing penury of timer in the plains in the course of historical times, were replaced by *Populus alba* and *P. canescens*. By vegetative propagation these have survived as well as some of the characteristic representatives of the herb and shurb strata of the oak stands. The responses of some sandy-steppe phytocenoses to increasing dryness of soil as well as the changes in species composition of these phytocenoses can be evaluated only in the knowledge of the hydroecological demands resp. tolerance of each species. These values for the characteristic species of the single stands can be determined in the same way as the contributions of species belonging to a particular hydroecological category to total coverage. Graphs plotted on the basis of the values further the better understanding of these relationships.

Materials and Methods

In the nature conservation area of sandy forest-steppe type at Ásotthalom, the sociological and hydroecological conditions of three associations and their smaller subunits were investigated with special regard to those physical and chemical parameters of the soil which influence principally the seasonal changes of the subunits.

In this paper only the results obtained during 1980 will be presented.

The distribution of soil fractions should be regarded as one of the most important influencing factors. For fractionation of soil the hydrometer method was used and complemented with sieving. The values for organic matter content, calcium carbonate content and the hy value were determined in early summer and late summer. Soil moisture was also measured.

The scales of ELLENBERG and ZÓLYOMI et al. for the expression of moisture demand and tolerance are commonly used in our country (SOÓ, 1964—80). This system contains ten categories and also a group of indifferent species. The hydroecological data collected and evaluated during the phytocenological and synecological investigations in the Great Plain for about 30 years alloved a more detailed hydroecological categorization of the species of the single phytocenoses. It was considered reasonable to eliminate the group of indifferent species, since each of its representatives can be listed into a suitable category. The single groups were marked with the abbreviated forms of their Latin names instead of numbers.

The new classification is the following:

1. hd (hydatophytes) species growing submersed or floating on the surface of standing and slowly flowing waters as well as species attached to some firm substrate.
2. hhe (hydato-helophytes) species growing in the littoral.
3. he (helophytes) species in damp, temporarily flooded habitats.
4. hhg (helo-hygrophytes) species of very humid, marshy, silty habitats.
5. hg (hygrophytes) species growing in moist environment.
6. mhg (meso-hygrophytes) species inhabiting slightly damp habitats.
7. m (mesophytes) species growing in medium dry situations.
8. xm (xero-mesophytes) species in drying habitats with a wide spectrum of hydroecological adaptability.
9. ax (asteno-xerophytes) species growing on dry soils.
10. sx (steno-xerophytes) species living in very dry situations (Species of low competitiveness on sand-hills, rocky slopes and loess ridges).

Further improving of the system was thought justified for the transitions. In the interest of that three sub-types were differentiated in each category. These were marked with figures. In this way, by using 28 sub-types, it was easy to solve the problems emerged (1 = transition to the previous category, 3 = transition to the next category).

For the identification of a particular species, it is very useful to plot the hydroecological graph of the species.

On the basis of literary and own data, namely, it is possible to determine the minimum and maximum points of the graphs for each species. The higher the percentual value for the maximum point, the nearer the minimum points to one another, i.e. the more characteristic the species from the aspect of hydroecology (their tolerance interval is narrow). In addition to the hydroecological characteristics for the single species, those for a particular phytocenosis can also be determined by means of the plotted graphs for the single species components. The complex graph can be plotted partly on the basis of species belonging to the single categories, partly on that of their contributions to cover.

It is desirable, however, to determine also the moisture content of the soil of each phytocenosis parallel with categorization. Differently from the practice adopted in the past when conclusions were drown on the basis of a single analysis, during these studies it was found more useful to take into account also the moisture content of the soil and express it in the percentage of wet resp. dry soil. These values were finally converted to lit dm^{-3}. In these analyses undisturbed sampling conditions were maintained. These three values for moisture content will be even more suggestive if in their graphical illustration their ratios are also considered (Fig. 3).

Discussion

Cenosystematical categorization of plant associations on the sandy forest-steppe of the protected area Emlékerdő (Soó, 1956, 1965–1980):

FESTUCO-BROMEA Jakucs 67

Festucetea vaginatae Soó 57

Festucetalia vaginatae Soó 57

Festucion vaginatae Soó 29

Festucetum vaginatae (RAPCS. 23) Soó 29 *danubialae* Soó 29

— — festucetosum vaginatae (typicum) MAGYAR 33

— — stipetosum borysthenicae (=sabulosae) (KERN 1863) Soó 39

— — populetosum albae-stoloniferae Soó (29) 39

Festucetalia valesiacae Soó 57

Festuco (rupicolae) — Salicetum rosmarinifoliae (MAGYAR 33) n.n.

(Syn.: Festucetum vaginatae salicetosum rosmarinifoliae)

— — festucetosum vaginatae (n.n.)

— — festucetosum rupicolae (typicum, n.n.)

— — poetosum angustifoliae (n.n)

— — molinietosum coeruleae (n.n.)

QUERCO-FAGEA Jakucs 67

Quercetea pubescentis-Petraeae (Oberd. 48) Jakucs 60

Quercetalia pubescentis Br-Bl. 31

Aceri tatarico-Quercion ZÓLYOMI et JAKUCS 63

Festuco (Querco)-Populetum (Soó n. prov. 71) BODRK. (57) 81

— — calamagrostetosum (n.n.)

— — festucetosum rupicolae (typicum, n.n.)

— — salicetosum rosmarinifoliae (n.n.)

Structure and synecology of the single associations and their sub-units (Fig. 1).
Festucetum vaginatae (RAPCS. 23) Soó 29/39 *danubiale* Soó 29/39.

The fluvial sand deposited and later left behind by the Danube retreating from the eastern part of the plain to the west may have become eolitic after drying and

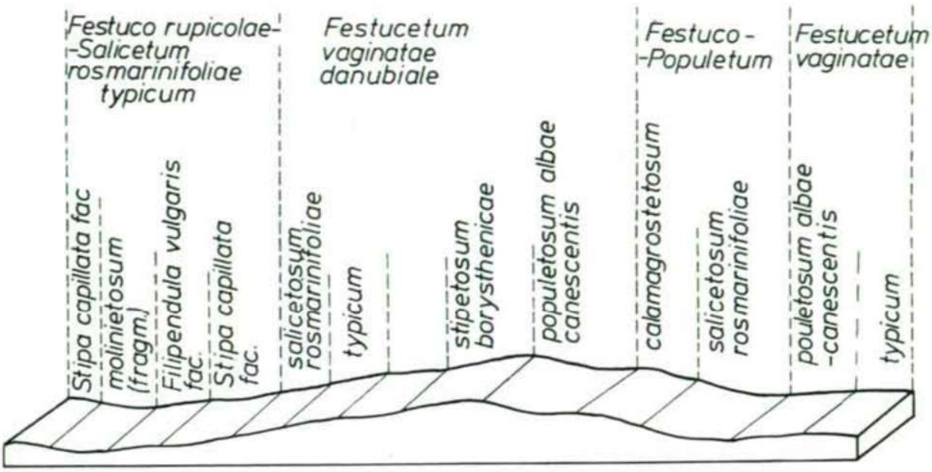

Fig. 1. Zonal distribution of plant communities in the area of investigation.

was delivered to shorter or longer distances by the wind. After several rearrangements, it formed hills, barkhans (BABOS, 1955). During this process, the coarse fraction separated out and the sand mass arriving to Szeged was of medium fine fraction. In the western areas of the region between the Danube and the Tisza, the coarse sand fraction predominates principally (SZABÓ, 1973). In our area, just as in the other sandy areas of our country, its stands occur on the sand-hills and higher sand ridges forming there open grass associations (HARGITAI, 1940; ZSOLT, 1943 ZÓLYOMI, 1958; BORHIDI, 1956; BODROGKÖZY, 1956, 1957; SIMON, 1962; PRÉCSÉNYI, 1961, 1963; SZODTFRIDT et al., 1968; KOVÁCS-LÁNG and SZABÓ, 1971), in which the moss-lichen synusium can assume a dominant role. VERSEGHY and KOVÁCS-LÁNG (1974) studied the structure and production of this association. These studies were concentrated only on the herb stratum.

It has more than one subassociations on the higher sand-hills and sand ridges at Ásotthalom:

F. v. festucetosum vaginatae (typicum) MAGYAR 33

A quarter of a century ago this was the dominant steppe grass variety. Today it is found only on the lower ridges. The distribution of its species according to the hydroecological categories is the following:

Though the species belonging to the subgroup of typical steno-xerophytes (sx2) exceed the sx3 species in respect of species number, evaluation of their contributions to the coverage points to the advantage of the latter ones (Table 1). During the last quarter of a century, *Stipa capillata* of the sx2 type has become gradually facies-forming together with ax3 *Calamagrostis epigeios*. The latter has two ecotypes: the asteno-xerophyte type growing on dry habitats and the hygro-mesophyte (hg1) one occurring in more humid environment along the river. Its occurrence in clearing vegetation is only transitory.

The xero-mesophytes exhibit great species numbers and low D values. These belong mainly to subgroup xm3, and their adaptability is greater than that of xm1 Scabiosa ochroleuca, Galium verum etc. (Table 1).

Table 1. Festucetum vaginatae danubiale stipetosum borystenicae (1), festucetosum vaginatae (2) populetosum albae (3)

	Subass.:					1	2	3
	Steno-xerophyta:							
H Festucion vaginatae	*Festuca vaginata*	sx3	F 2	T 4	N 1			
H Festucion vaginatae	*Stipa borysthenica*	sx3	F 2	T 3–4	N 1			
H Festucion vaginatae	*Euphoria seguieriana*	sx3	F 1–2	T 3	N 1			
H Festucion vaginatae	*Tragopogon floccosum*	sx3	F 1–2	T 4	N 2–3			
H Festucion vaginatae	*Alkanna tinctoria*	sx3	F 1	T 4–5	N 1			
N Festucetalia vaginatae	*Fumana procumbens*	sx3	F 1–2	T 4	N 1			
H Festucion vaginatae	*Dianthus diutinus*	sx3	F 1–2	T 4	N 1			
G Festucetalia vaginatae	*Carex liparicarpos*	sx2	F 2	T 4	N 2			
H Festucion vaginatae	*Stipa capillata*	sx2	F 2	T 3–4	N 2			
Ch Festucion vaginatae	*Alyssum tortuosum*	sx2	F 2	T 3–4	N 1			
H Festucion vaginatae	*Koeleria glauca*	sx2	F 2	T 3	N 2			
H Festucion vaginatae	*Centaurea arenaria* ssp. *tauscheri*	sx2	F 2	T 4	N 1			
H Festucion vaginatae	*Syrenia cana*	sx2	F 2	T 4	N 1			
H Festucion vaginatae	*Onosma arenaria*	sx2	F 1–2	T 4	N 1			
Ch Festucion vaginatae	*Dianthus serotinus*	sx2	F 1–2	T 4	N 1			
Ch Festucetalia valesiacae	*Thymus marschallianus*	sx1	F 1–2	T 3	N 1			
Th Festucion vaginatae	*Salsola kali* ssp. *ruthenica*	sx1	F 1–2	T 3	N 0			
G Festucetalia valesiacae	*Equisetum ramosissimum*	sx1	F 2	T 3–4	N 0			
Th Bromion tectorum	*Secale silvestris*	sx1	F 1–2	T 4	N 1			
	Asteno-xerophyta:							
H Populetalia	*Calamagrostis epigeios*	ax3	F 2–3	T 3	N 3			
Th Festuco-Brometea	*Verbascum lychnitis*	ax3	F 2	T 3	N 2–3			
H Festuco-Brometea	*Linaria genistifolia*	ax3	F 2	T 4	N 2			
Th Festucion vaginatae	*Polygonum arenarium*	ax2	F 1–2	T 4	N 1–2			
Th Bromion tectorum	*Tragus racemosus*	ax2	F 2	T 4–5	N 2			
Ch Festucetalia valesiacae	*Artemisia campestris*	ax1	F 2	T 2	N 2			
G Festuco-Bromea	*Cynodon dactylon*	ax1	F 2	T 3–4	N 3			
Th Festucetalia valesiacae	*Minuartia glomerata*	sx1	F 1–2	T 4	N 1–2			
Th Festucion vaginatae	*Alyssum tortuosum*	sx1	F 2	T 3–4	N 1–2			
H Festuco-Brometea	*Phleum phleoides*	ax1	F 2	T 3	N 2			
H Festucetalia vaginatae	*Silene otites* ssp. *pseudotites*	ax1	F 2	T 3	N 2			
Ch Festuco-Brometea	*Teucrium chamaedrys*	ax1	F 1–2	T 2	N 2			
H Festucetalia valesiacae	*Minuartia verna*	ax1	F 1–2	T 0	N 1–2			
Ch Festucetalia valesiacae	*Alyssum montanum* ssp. *gmelini*	ax1	F 2	T 3	N 1			
H Festucetalia valesiacae	*Chrysopogon gryllus*	ax1	F 2	T 3–4	N 2			
	Xero-mesophyta:							
H Festucetalia	*Poa angustifolia*	xm3	F 3	T 0	N 3			
Th Festuco-Bromea	*Arenaria serpyllifolia*	xm3	F 2–3	T 0	N 2–3			
H Festuco-Brometea	*Eryngium campestre*	xm3	F 1	T 4	N 2–3			
H Festuco-Brometea	*Scabiosa ochroleuca*	xm3	F 1–2	T 3–4	N 1			
Th Festuco- Brometea	*Odontites lutea*	xm3	F 2	T 4	N 1–2			
H Festuco-Brometea	*Euphorbia cyparissias*	xm3	F 1–2	T 0	N 0			
H Festucetalia valesiacae	*Astragalus onobrychis*	xm3	F 1	T 3	N 1			
H Festucion vaginatae	*Chondrylla juncea*	xm3	F 2–3	T 4	N 2			
Th Festucetalia valesiacae	*Medicago minima*	xm3	F 1–2	T 1–2	N 2			
Th Festuco-Brometea	*Erophila verna*	xm3	F 2–3	T 0	N 1–2			
Th Festuco-Brometea	*Calamintha acynos*	xm3	F 1–2	T 2–3	N 2			
Th Chenopodio-Scleranthea	*Camelina microcarpa*	xm3	F 2–3	T 3	N 2–3			

Subass.:						1	2	3
Th Secalietea	*Crepis rhoeadifolia*	xm3	F 2–3	T 4	N 2–3	——	——	……
H Festucetalia valesiacae	*Dianthus pontederae*	xm2	F 2	T 4	N 2		……	……
Th Secalietea	*Consolida regalis*	xm2	F 2	T 3	N 2	……	……	
G Festucetalia valesiacae	*Iris humilis* ssp. *arenaria*	xm2	F 2	T 3	N 1–2	……	……	
H Festuco-Brometea	*Galium verum*	xm1	F 0	T 2–3	N 1–2	……	——	——
Th Festuco-Brometea	*Holosteum umbellatum*	xm1	F 2	T 4	N 2–3	……	……	
M Populetalia	*Populus alba*	xm1	F 2–3	T 4	N 1–2	……	……	▬▬▬
M Populetalia	*Populus canescens*	xm1	F 2–3	T 4	N 1–2		……	▬▬▬

Signes used (D%)

▬▬▬ 25–50
▬▬▬ 10–25
▬▬▬ 5–10
…… 1–5

F.v. stipetosum borysthenicae (KERN, 1863) SOÓ 39 corr. n.

It is found on the dryest sand-hills and sand ridges in our area. During the last decades it has gained ground considerably (BODROGKÖZY, 1957). This is likely to be related to the more intensive drying of sandy areas as a consequence of the operation of the canal systems in the interest of regulating internal waters.

Seasonal changes of its environmental factors

In the organis matter-poor, medium fine sandy soil of its stands (Fig. 4) the clay-silt fraction is minimal: its ability to bind precipitation is small. Studies performed by SZABÓ (1973) are also in support of that. The small difference between the courses of the graphs for soil moisture expressed in the percentages of dry and wet soil weight throughout the vegetation period also indicates that. At the same time, in the vernal aspect, precipitation is abundant, the number of sunny hours of the day decreases (during 20 days before the examination 64 mm: Fig. 2, 3).

Despite repeated atmospheric precipitation in early summer, 1980, the water regime appeared to be unfavourable, but for the low dead water content, the grass stand was still green. By the end of August, however, the value for soil moisture near the surface was only 0.01 lit dm^{-3} and the vegetation was discoloured.

Hydroecological characterization of its species

The number of sx species is greater relative to the type; concerning contribution to coverage, *Stipa borysthenica* dominated. Its gaining ground at the expense of *Festuca vaginata* seems to be related to the increasing drying of the environment (Fig. 5).

Similarly to the type, the number of xero-mesophytes with wider ecological adaptability is greater, but their total contribution to cover is smaller. These belong mostly to xm3 subgroup and have greater rooting depths. Such are e.g. *Chondrilla juneca, Eryngium campestre* etc. Of the therophytes only those survived, which bloom under the more favourable hydroecological conditions of the vernal aspect, as *Arenaria serpyllifolia, Erophila verna, Medicago minima*, etc.

The 19 stenoxerophytes are species of Festucion vaginatae from the viewpoint of cenosystematics, apart from a few exceptions. One of the most important members

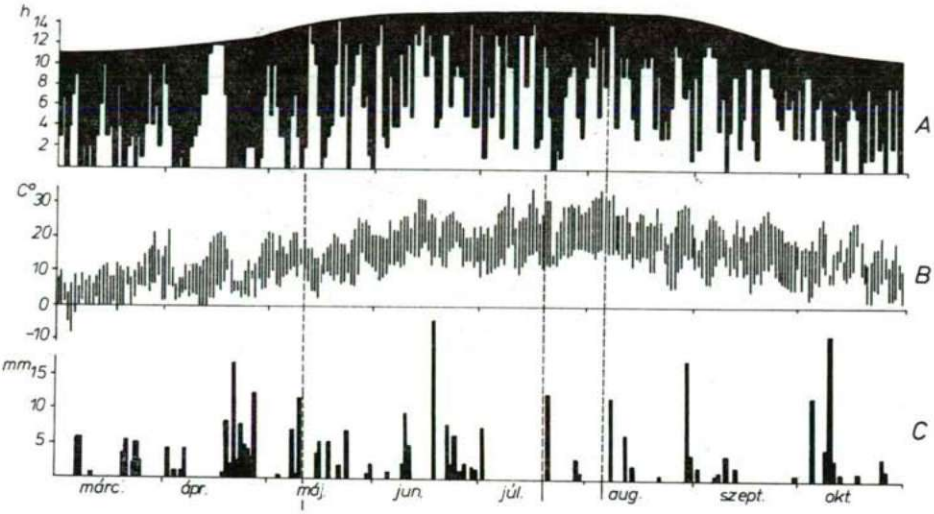

Fig. 2. Diel rhythm of the components in the vegetation period of 1980.
A: Distribution of sunlit and cloudy hours, B: Daily maxima and minima of air temperature, C: Precipitation in March, April, May, June, July, August, September and October.

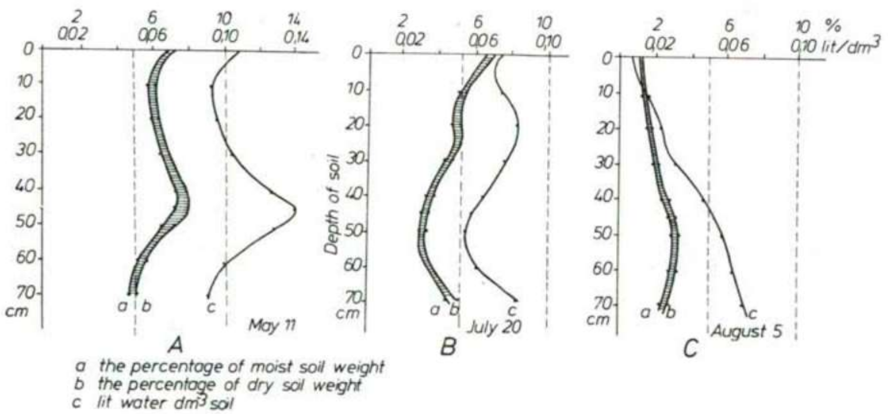

Fig. 3. Changes of moisture dynamics in the humus-poor quick sand profile of hill top soil in the vernal resp. aestival aspect in 1980.
a: the percentage of moist soil weight; b: the percentage of dry soil weight; c: lit water dm^{-3} soil.

of this subassociation from the aspect of nature conservation is *Dianthus diutinus* the endemic species of the sandy steppes between the Danube and the Tisza. Recently it has diminished considerably.

F. v. populetosum albae-canescentis (Soó) 29/39

The two poplar species *Populus alba* and *P. canescens* can even ascend the lower sand-hills and sand ridges by means of their sprouts. For the unsufficient nutrient and moisture supply, however, they can only form shrubberies there. Owing to

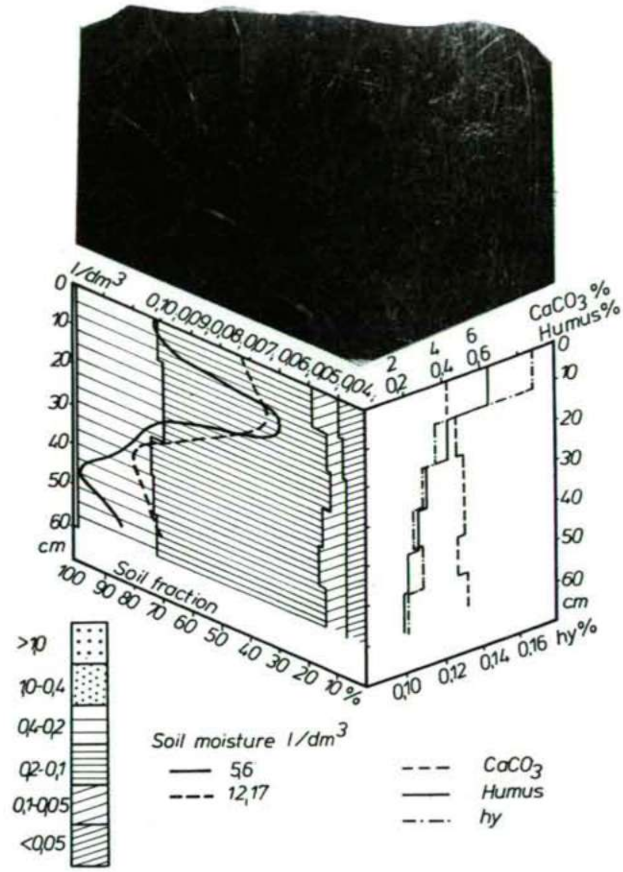

Fig. 4. Physical, chemical and water dynamical conditions in the soil profile of the plant community on sand hill top in 1980.

Fig. 5. Hydroecological graphs for the species components of open sandy steppe
mhg: mesohygrophyton, m: mesophyton, xm: xeromesophyton, ax: astenoxerophyton, sx: stenoxerophyton.

their shading effect several such species appear which were missing from the former two subassociations, or occur only sparsely there as Poa angustifolia and the facies-forming ax3 Calamagrostis epigeios (Table 1). The latter one has increased in the last quarter of a century and contributed to the further drying of the habitat. Analytical data pertaining to the condition of its soil are known (BODROGKÖZY, 1975).

Festuco rupicolae-Salicetum rosmarinifoliae (MAGYAR 33) n.n.

Before the regulation of internal waters, the underground water table lying higher in the sandy areas of the region between the Danube and the Tisza complemented with the accumulating stagnant waters resulted in the formation of marshes between the sand-hills. The stands of *Molino-Salicetum rosmarinifoliae* (MAGYAR 33) Soó 57 made up of Molinion and Agrostion components dried out gradually as a consequence of the lowering of underground water level, giving place for the species of Festucetalia and Festuco-Brometea.

The oxidation of humus in its soil as well as the secondary sand cover in some places, caused the species of Festucetalia, moreover those of Festucion vaginatae to became dominant in the higherlying places between the sand-hills. In this way another independent association formed between *Festucetum vaginatae* and *Molinio-Salicetum rosmarinifoliae* (MAGYAR, 1933). Its two character species *Holoschoenus romanus* and *Salix repen*-ssp. *rosmarinifolia* cannot be regarded as characters pecies of Festucetum vaginatae. The type is linked with the (above mentioned) adjacent associations by subassociations of transitory nature. It is also likely to be connected with *Astragalo-Festucetum (sulcatae) rupicolae* (BODROGKÖZY, 1957).
Its soil ecology

It is particularly its more favourable organic matter content and water supply relative to the former one, that assure better conditions of life which is evident first of all in the vernal aspect (Fig. 6). Its single subassociations, however, essentially differ from one another:

F.(r). — S.r. festucetosum vaginatae (n.n)

(Syn.: Festucetum vaginatae salicetosum rosmarinifoliae (Magyar 33) Soó 39).

It is a transition to Festucetum vaginatae, forming a zone at higher levels of the spaces between the sand-hills (Fig. 1). During the last decades, it has spread very greatly in our area. It is, however, well separated by *Salix rosmarinifolia* and *Holoschoenus romanus*.

Hydroecological position

In respect of the distribution of species, sx2 type species have become dominant instead of sx3 components within the category of stenoxerophytes. Type sx2 *Stipa capillata,* sporadically *Chrysopogon gryllus* occur in large numbers and with increasing frequency. The xeromesophytes are still crowded into the background (Table 3, Fig. 11). The hydroecological plots of some character species also show the transitory nature of this subassociation (Fig. 6).

F(r)–S.r. festucetosum rupicolae (typicum) n.n.

In the Danube–Tisza midregion, and thus also in the protected area of Emlékerdő, the impoverished meadow communities between the sand-hills in the sandy forest-steppe separate into well distinguishable facies. Their occurrence shows cor-

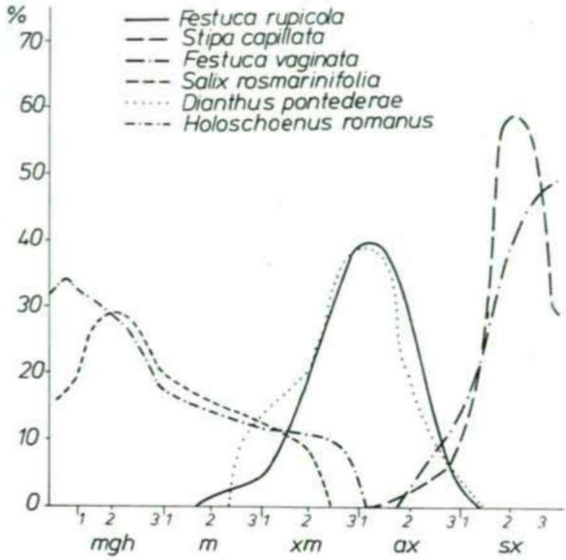

Fig. 6. Hydroecological graphs for the character species of a transitional stand of *Festuca vaginata* in the meadow between sand-hills.

relation with the seasonal changes of the water regime in the vegetation period. The thing they have in common is that after the favourable moisture supply during spring a very dry period follows in summer during which the water content of soil in their rooting zone is less than 0,05 lit dm^{-3} (Figs. 7, 8).

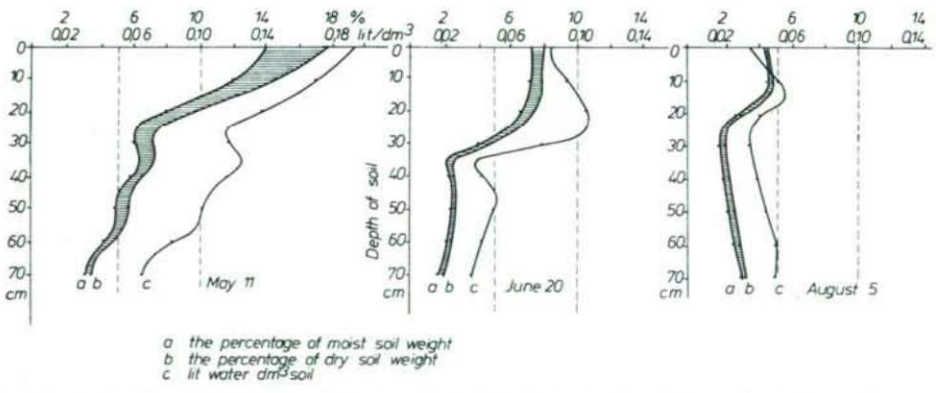

Fig. 7. Changes of moisture content in the humous sandy soil profile of typical meadov plant community in the space between sand-hills.
a: the percentage of moist soil weight; b: the percentage of dry soil weight;
c: lit water dm^{-3} soil.

Stipa capillata facies

This is closest related to the previous subassociation in respect of species composition, but the contribution of Salix repens ssp. rosmarinifolia to cover is essentially greater. The water regime of its soil is much better than that of the previous facies.

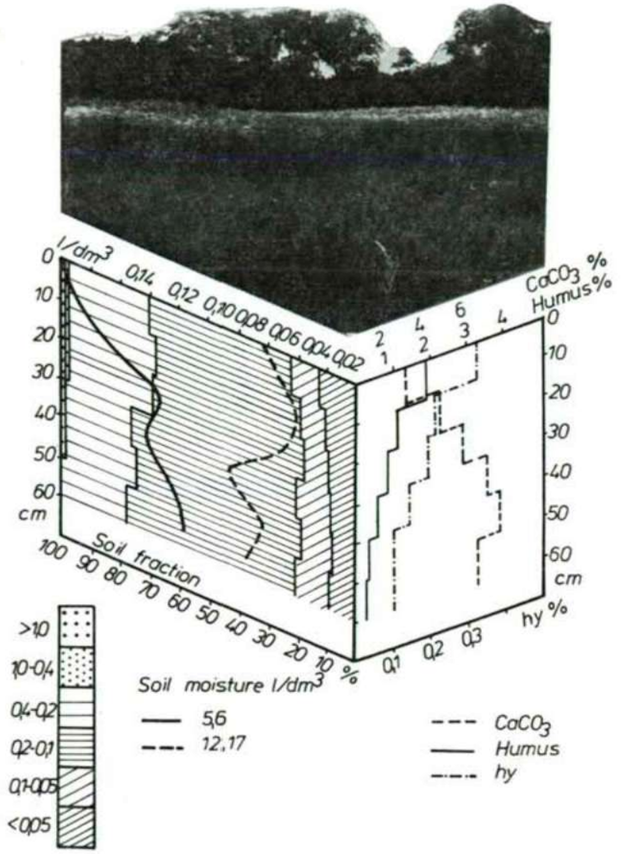

Fig. 8. Physical and chemical properties of the soil profile between sand-hills as well as the maximal and minimal values of its water budget in 1980.

It can be characterized by a more favourable organic matter supply, which is due partly to the higher phytomass production (Table 4) and decomposition and partly to the excellent water-binding capacity of humus carried down from the sand-hills by the wind. Here the possibilities of binding resp. storing atmospheric precipitation are better. In the surface-near soil layers, twice as much water was demonstrable than in the neighbouring hill top in its vernal aspect in 1980. The water regime in deeper soil layers is, however, more balanced (Fig. 7). This facies is the poorest one of the subassociation. Its character species are sx2 *Stipa capillata*, ax1 *Festuca rupicola* as well as *Poa angustifolia, Potentilla arenaria, Stachys recta* of the xm3 type each and *Medicago falcata* and *Linum austriacum* both belonging to the type xm2. Species of the mhg type *Salix repens* ssp. *rosmarinifolia* and *Polygala comosa.*

Filipendula vulgaris facies

It is found in the richest sections of the former marshy meadows among the sand-hills, in the northern littoral zone of windformed ridges, where the shading effect of nearby poplar stands prevails. In the summer period ot is much better protected against the damaging effect of insolation. Its stands are completely closed with double herb stratum. Organic matter content of its soil is higher than that of the former facies (Fig. 10). Its water regime is better, but the root effect of the nearby poplar stands prevails in a considerable measure particularly during summer (Fig. 9).

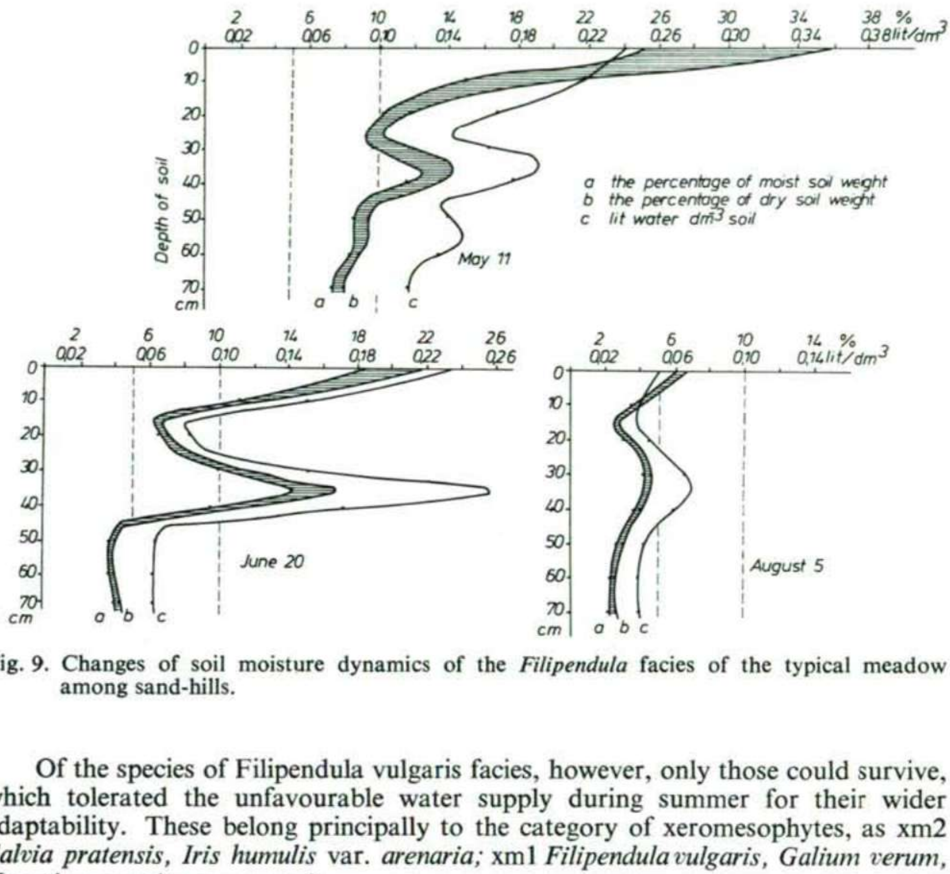

Fig. 9. Changes of soil moisture dynamics of the *Filipendula* facies of the typical meadow among sand-hills.

Of the species of Filipendula vulgaris facies, however, only those could survive, which tolerated the unfavourable water supply during summer for their wider adaptability. These belong principally to the category of xeromesophytes, as xm2 *Salvia pratensis*, *Iris humulis* var. *arenaria;* xm1 *Filipendula vulgaris*, *Galium verum*, *Knautia arvensis* ssp. *arvensis*.

Members of Molino-Arrhenatheretea are m3 *Tragopogon orientalis* as well as *Lotus corniculatus* and *Ranunculus acris* of the m2 type both. Moreover, in some places as species of Molinietalia, the hygrophyte *Thalictrum simplex* v. *galioides* and the characteristic name-giving species of the ancient marshy meadows in the spaces between hillocks *Molinia coerulea* are also observable occurring by stems (Table 2).

The percentual values for the contributions of species belonging to the single hydroecological categories to coverage in comparison with similar values for *Festuca vaginata* subassociation are shown in Fig. 11. It is seen that the plotted graph for species components of *Festuca rupicola* subass. culminates in the ax1 subtype which forms a link between xero- and astenoxerophytes, while in the case of the subass. *Festuca vaginata* at sx2 (Fig. 11).

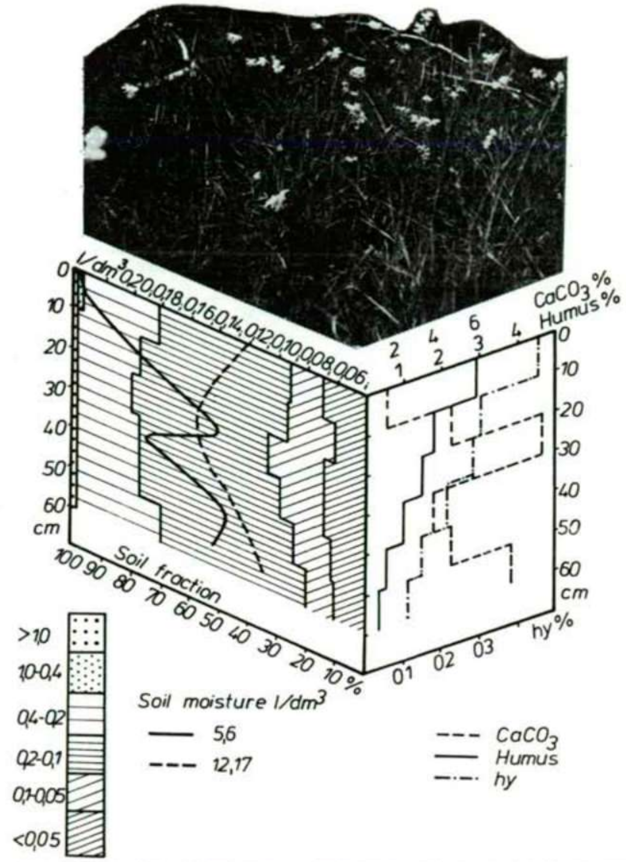

Fig. 10. Data on the soil profile of the *Filipendula* type zone among the sand-hills.

F(r)–S.r. molinietosum coeruleae (n.n)

It occurs in the deepest wind furrows in the area of sandy forest-steppe type of Emlékerdő, albeit its occurrence has also been sporadic a querter of a century ago. Independently from this, it forms good connections with *Molinio-Salicetum rosmarinifoliae* described from other areas of the Duna–Tisza midregion. Namely, these spaces among the hillocks must have been more deeper-lying in the past than today. In one of the wind furrows, the soil surface of the old marshy meadow is found at 80 cm depth. Its hy value indicates that the humus meadow sandy soil is harder here (Bodrogközy, 1957). Its present level was formed by the rearrangement of the sand masses in the region. Following the invasion and closing of *Festuca rupicola* in this area further superposition of sand could not have taken place. Later, the accumulation of organic matter on the surface resulted in the formation of humuscontaining sandy surface soil.

Hydroecology

The moisture content of its soil as expressed in lit dm^{-3} unit was never as high in the vernal aspect measured after a more abundant atmospheric precipitation as in the zone among the hillocks exposed to the shading effect of the trees. In late summer the dynamics of water proved to be unfavourable in the soil of this subassociation, too (Figs. 12, 13).

Because of the competition for space for root caused by the closing of *Festuca rupicola,* its cenoses contain less species than the previous subassociations. Of the character species of the original *Molinio-Salicetum rosmarinifoliae* only *Serratula*

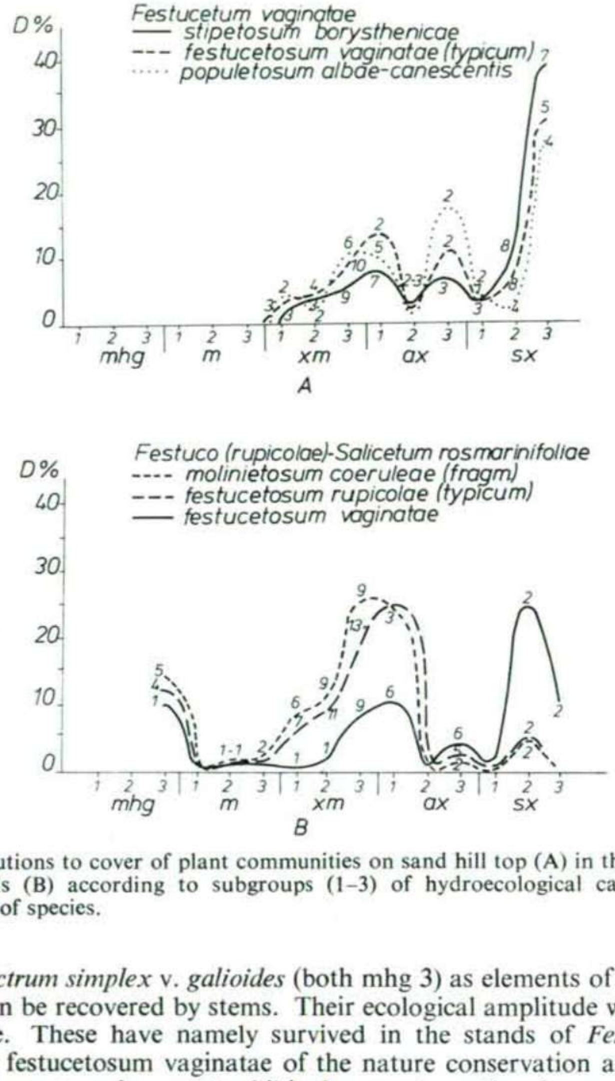

Fig. 11. Contributions to cover of plant communities on sand hill top (A) in the spaces between sand-hills (B) according to subgroups (1–3) of hydroecological categories and the number of species.

tinctoria, Thalictrum simplex v. *galioides* (both mhg 3) as elements of Molinion resp. Molinietalia can be recovered by stems. Their ecological amplitude was found to be extremely wide. These have namely survived in the stands of *Festuco-Salicetum rosmarinifoliae* festucetosum vaginatae of the nature conservation area, and in the last quarter of a century have not exhibited any noteworthy changes. On the other hand, *Linum catharticum* perished. At the same time, the Festucetalia valesiacae species, *Chrysopogon gryllus* as well as *Anthericum ramosum* the relict species of old steppe oak forests have immigrated. During the last decades, *Stipa capillata* has become facies-forming species and spread very greatly (Table 2).

Table 2. Festuco (rupicolae) -Salicetum rosmarinifoliae molinietosum coeruleae (1), festucetosum rupicolae (2) festucetosum vaginatae (3).

							Subass.: 1	2	3
	Steno-xerophyta:								
H	Festucion vaginatae	*Festuca vaginata*	sx3	F 3	T 4	N 1			▬
H	Festucion vaginatae	*Euphorbia seguieriana*	sx3	F 1–2	T 3	N 1			····
H	Festucion vaginatae	*Stipa capillata*	sx2	F 2	T 3–4	N 2	▬	▬	▬
G	Festucetalia vaginatae	*Carex liparicarpos*	sx2	F 2	T 4	N 2			····
H	Festucion vaginatae	*Carex arenaria* ssp. *tauscheri*	sx2	F 2	T 4	N 1		····	····
H	Festucion vaginatae	*Onobrychis aranifera*	sx2	F 1	T 3	N 1	····		····
H	Festucion vaginatae	*Syrenia cana*	sx2	F 2	T 4	N 1			····
H	Festucion vaginatae	*Tragopogon floccosum*	sx2	F 1–2	T 4	N 1			····
Th	Festucetalia valesiacae	*Bromus squarrosus*	sx2	F 2	T 4	N 2			····
Th	Bromion tectorum	*Secale silvestris*	sx1	F 1–2	T 4	N 1			····
H	Festucetalia valesiacae	*Anthericum ramosum*	sx1	F 2	T 4	N 2		····	····
	Asteno-xerophyta:								
Th	Festuco-Brometea	*Verbascum lychnitis*	ax3	F 2	T 3	N 2–3	····	····	····
Ch	Festucetalia valesiacae	*Thymus marschallianus*	ax3	F 1–2	T 3	N 1	····	····	····
H	Festuco-Brometea	*Botriochloa ischaemum*	ax3	F 2	T 3–4	N 2		····	····
H	Quercetea	*Inula salicina* v. *denticulata*	ax3	F 2–3	T 3	N 2		····	····
Th	Festucetalia valesiacae	*Viola kitaibeliana*	ax3	F 2	T 4	N 2		····	····
H	Festuco-Brometea	*Linaria genistifolia*	ax3	F 2	T 4	N 2			····
H	Populetalia	*Calamagrostis epigeios*	ax3	F 2–3	T 3	N 3			····
H	Festucetalia valesiacae	*Festuca rupicola*	ax1	F 2	T 3	N 2	▬	▬	▬
H	Festucetalia valesiacae	*Asperula cynanchica*	ax2	F 1–2	T 4	N 1	····	—	—
H	Festuco-Brometea	*Teucrium chamaedrys*	ax1	F 1–2	T 2	N 2	—	····	····
H	Festuco-Brometea	*Phleum phleoides*	ax1	F 2	T 3	N 2		····	—
H	Festuco-Brometalia	*Poa bulbosa*	ax1	F 1–2	T 3–4	N 1		····	—
G	Festuco-Brometea	*Muscari racemosum*	ax1	F 2	T 4	N 2		····	····
Th	Festuco-Brometea	*Saxifraga tridactylites*	ax1	F 2	T 3	N 2		····	
H	Festucetalia valesiacae	*Campanula sibirica*	ax1	F 2	T 3–4	N 1–2	····	····	
	Xero-mesophya:								
H	Festuco-Brometea	*Poa angustifolia*	xm3	F 2	T 2	N 3	▬	▬	—
H	Festuco-Brometea	*Euphorbia cyparissias*	xm3	F 1–2	T 0	N 0	—	—	····
H	Festucetalia valesiacae	*Astragalus onobrychis*	xm3	F 1	T 3	N 1	····	—	—
H	Festucetalia valesiacae	*Potentilla arenaria*	xm3	F 1–2	T 3	N 2	—	—	····
H	Festucetalia valesiacae	*Stachys recta*	xm3	F 1–2	T 3	N 2	—	—	
Th	Festuco-Brometea	*Seseli annuum*	xm3	F 1–2	T 3	N 2	····	····	····
Th	Festuco-Brometea	*Odontites lutea*	xm3	F 2	T 4	N 1–2		····	····
H	Festucion rupicolae	*Astragalus austriacus*	xm3	F 1	T 3	N 1		····	····
H	Festucetalia valesiacae	*Anthyllis vulneraria* ssp. *polyphylla*	xm3	F 1–2	T 3	N 1	····	····	
H	Festucetalia	*Cynanchum vincetoxicum*	xm3	F 1–2	T 3	N 2	····	····	
Th	Festuco-Brometea	*Erophyla verna*	xm3	F 2–3	T 0	N 1–2		····	····
H	Festuco-Brometea	*Eryngium campestre*	xm3	F 1	T 4	N 2–3			····
Th	Festuco-Brometea	*Arabis recta*	xm3	F 2	T 4	N 2			····
Th	Festucion rupicolae	*Thesium arvense*	xm3	F 2	T 3	N 2	····		
Ch	Festucetalia	*Veronica prostrata*	xm3	F 2	T 3	N 1–2		····	
H	Festucetalia valesiacae	*Verbascum phoeniceum*	xm3	F 2–3	T 4	N 2		····	
H	Festuco-Brometea	*Salvia pratensis*	xm2	F 2	T 2	N 2	▬	▬	
H	Festucetalia valesiacae	*Dianthus pontederae*	xm3	F 2	T 4	N 2	—	····	····
G	Festuco-Brometea	*Asparagus officinalis*	xm2	F 2	T 3	N 2–3		····	····
H	Festuco-Brometea	*Coronilla varia*	xm2	F 1–2	T 3	N 1–2	····	····	

						Subass.:	1	2	3
G	Festucetalia valesiacae	*Iris humilis* ssp. *arenaria*	xm2	F 2	T 3	N 1–2	....	....	
H	Festuco-Brometea	*Medicago falcata*	xm2	F 1–2	T 3	N 2	....	....	
H	Festucion rupicolae	*Linum austriacum*	xm2	F 1–2	T 3–4	N 1	....	....	
H	Festuco-Brometea	*Ononis spinosa*	xm2	F 2–3	T 3	N 3		....	
H	Festucetalia	*Scorzonera purpurea*	xm2	F 2	T 4	N 2	....	....	
Th	Festuco-Brometea	*Thlaspi perfoliatum*	xm2	F 3	T 3–4	N 2		....	
Th	Festuco-Brometea	*Carduus nutans*	xm2	F 2–3	T 0	N 3–4		....	
Th	Festuco-Brometea	*Erigeron acris*	xm2	F 2–3	T 2	N 2–3	....		
M	Populetalia	*Populus alba*	xm1	F 0	T 3	N 1	——	....	....
H	Festuco-Brometea	*Galium verum*	xm1	F 0	T 2–3	N 1–2	——	▬▬	
H	Festuco-Brometea	*Filipendula vulgaris*	xm1	F 3	T 3	N 1	——	▬▬	
H	Festucetalia valesiacae	*Knautia arvensis* ssp. *arvensis*	xm1	F 2–3	T 2–3	N 0	....	....	
Th	Festuco-Brometea	*Holosteum umbellatum*	xm1	F 2	T 4	N 2–3	....	....	
Th	Secalietea	*Lithospermum arvense*	xm1	F 2	T 2	N 2–3	....	....	
Th	Chenopodietea	*Senecio vernalis*	xm1	F 2–3	T 3–4	N 3		....	
		Mesophyta:							
Th	Arrhenatheretea	*Tragopogon orientalis*	m3	F 2–3	T 2–3	N 2–3	——	——	
Th	Secalietea	*Veronica arvensis*	m3	F 3	T 2	N 3		....	....
H	Molinio-Arrhenath.	*Lotus corniculatus*	m2	F 0	T 0	N 2–3	——	....	
H	Molinio-Arrhenath.	*Ranunculus acris*	m2	F 0	T 0	N 2–3		——	
		Meso-hygrophyta:							
H	Molinietalia	*Salix rosmarinifolia*	mhg3	F 3	T 2	N 1–2	▬▬	▬▬	▬▬
H	Molinio-Arrhenath.	*Polygala comosa*	mhg3	F 0	T 3	N 1	——	....	
G	Festucion vaginatae	*Holoschoenus romanus*	mhg1	F 0	T 4	N 2	....	....	....
H	Molinietalia	*Thalictrum simplex* v. *galioides*	mhg3	F 3–4	T 3–4	N 2	——	....	
H	Molinio-Arrhenath.	*Serratula tinctoria*	mhg3	F 3–4	T 3	N 2	....		
		Hygrophyton:							
H	Molinion	*Molinia coerulea*	hg 1	F 2–3	T 3	N 1–2	....		

Festuco (Querco)-Populetum albae (Soó 71 nom. prov) n.n.

(Syn.: *Festuco (Populo) — Quercetum* (HARGITAI 40) Soó 71 n. prov. *Festuco-Quercetum* populetosum albae BODRK. 57).

Both for its species and its ecological conditions, this association is related to the stands of *Junipero-Populetum albae* (RAPCS. 22) ZÓLYOMI ex Soó 50 em. SZODTFRIDT 69. Occurrence and differentiation of its subunits of association seem to be connected with the places of occurrence of the ancient oak forests of sandy steppe type in our area. The *Populus alba* and *P. canescens* and their forms of transition (ex verb I. MARÓTI) could form well developed stands only in such places, where sufficient nutrient and moisture supply was secured for them by the humous sandy or brown forest soil covered by way of secondary sand movement in ancient oak forests (BODROGKÖZY, 1957). As a consequence of gradual drying in the course of historical times, the stands of *Populus* species do not proliferate any more generatively. They can only renew vegetatively. The process of ageing has been, however, so severe that no renewal could be observed even under the favourable light conditions of

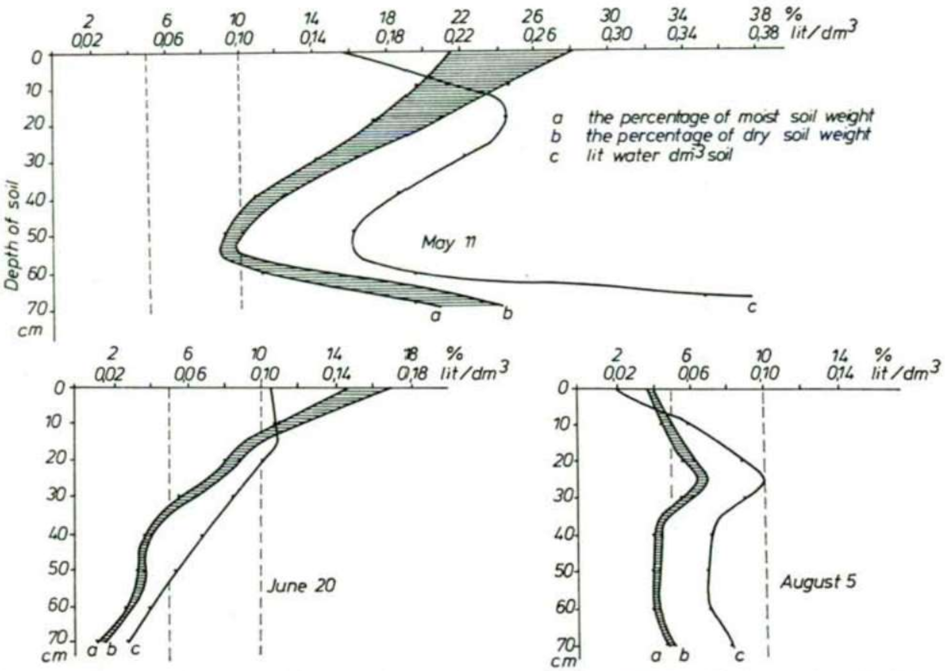

Fig. 12. Changes of soil humidity in the meadow between sand-hills with fragments of *Molinia* subass during the vegetation period.
a: the percentage of moist soil weight; b: the percentage of dry soil weight;
c: lit water dm^3 soil.

gallery-forest-like stands. In our plain the frequently occurring violent wind-storms can be the cause of great havoc in the about 80-year-old poplar stands. Thus we have to reckon with the gradual extinction of these stands.

Ecological conditions

Its soil profile contains a very small silty fraction and the fine sand dominates (Fig. 14). The buried humus level occurs everywhere (BODROGKÖZY, 1957). On the basis of that and on that of the different degrees of water supply we can distinguish the following subunits of this association:

F.(Qu.)–P.a. calamagrostetosum BODRK. (57) n. corr.

(Syn.: *Festuco-Quercetum* populetosum albae xerophilum Bodrk. 57).

It is found on the sand ridges surrounding the depressions, where the buried humus layer contains less organic matter and occurs below 100 cm depth.

It is characteristic of its hydroecological condition that the ratio of moisture content per dry soil weight to that per wet soil weight and the ratio of moisture content in lit per dm^3 dry soil to that of the wet soil was only in the vernal aspect, principally in the surface-near soil layers favourable in 1980. By the end of summer the value for moisture content was only 60 ml cm^3. Changes in these values are illustrated in Figs. 14 and 15.

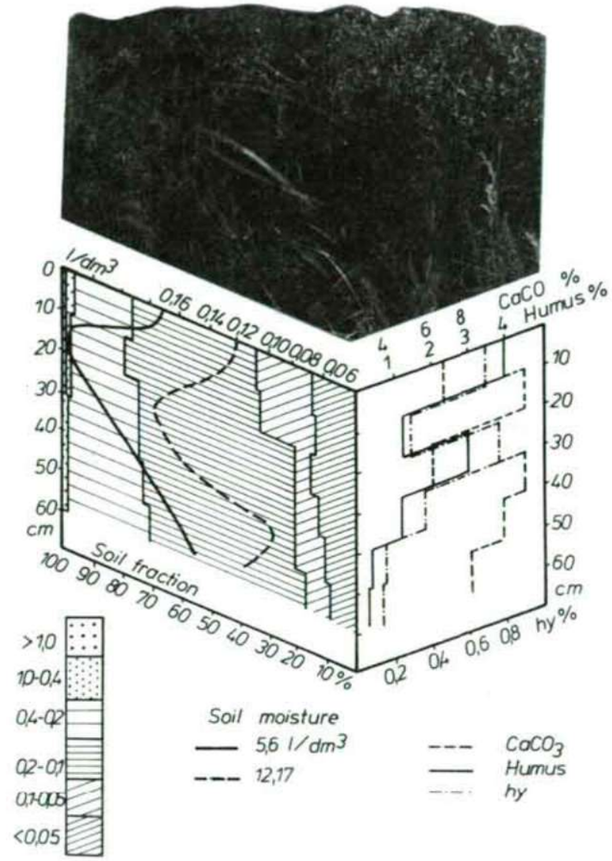

Fig. 13. Analytical data of the soil profile between sand-hills with fragments of *Molinio-Salicetum*.

Species composition

Its tree stratum is made up of *Populus alba* and *P. canescens* with never closing foliage. Its shrub stratum is made up of *Crataegus monogyna, Berberis vulgaris; Juniperus communis* is missing. Its herb stratum is fairly well lighted, which explains the dominance of species of Festucetalia valesiacae and Festuco-Brometea there and the increasing abundance of type ax3 *Calamagrostis epigeios*. This species has two well differenciable ecotypes in the Great Plain. It can be regarded as a meso-hygrophyte in its habitats along the rivers, and astenoxerophyte in the sandy steppes.

Among its species xeromesophytes also occur with greater species number besides steno- and astenoxerophytes. The xeromesophytes belong to the xm3 subtype. *Poa angustifolia* is a dominant species. The contributions of *Galium verum, Dianthus pontederae* etc. to coverage are smaller (Table 3, Fig. 16).

F. (Qu)–P.a. festucetosum rupicolae (typicum) n.n.

It occurs in more favourable situations than the previous one. Its tree stratum is more closed and the species composition of its herb stratum changes. Its shrub

Table 3. Festuco (Querceto) — Populetum
calamagrostetosum (1), festucetosum rupicolae (2), salicetosum rosmarinifoliae (3).

							Subass.: 1	2	3
MM	Populetalia	*Populus alba*	xm1						
MM	Populetalia	*Populus canescens*	xm1						
M	Quercetea	*Crataegus monogyna*	xm3	T 2–3	T 4	N 2			
M	Quercetea	*Berberis vulgaris*	xm3	F 2	T 4	N 2			
M	Quercion pubesc.	*Ligustrum vulgare*	xm2	F 2–3	T 3	N 2			
M	Molinietalia	*Salix repens* ssp. *rosmarinifolia*	mhg3	F 3	T 2	N 1–2			
M	Quercetea	*Cornus sanguinea*	xm2	F 2–3	T 4	N 2			
	Lawn-level								
		Steno-xerophyta:							
H	Festucetalia vag.	*Festuca vaginata*	sx3	F 2	T 4	N 1			
H	Festucetalia vag.	*Tragopogon floccosum*	sx3	F 1–2	T 4	N 1			
H	Festucion vag.	*Onobrychis aranifera*	sx2	F 1	T 3	N 1			
H	Festucetalia vag.	*Carex liparicarpos*	sx2	F 2	T 4	N 2			
		Asteno-xerophyta:							
H	Populetalia	*Calamagrostis epigeios*	ax3	F 1–2	T 3	N 3			
H	Festucetalia vales.	*Asperula cynanchica*	ax2	F 1–2	T 4	N 1			
H	Festucetalia vales.	*Festuca rupicola*	ax1	F 2	T 3	N 2			
H	Festucetalia vales.	*Festuca valesiaca*	ax1	F 2	T 3	N 2			
H	Quercetea	*Thalictrum minus*	ax1	F 1–3	T 2–3	N 1–2			
Ch	Festuco-Brometea	*Teucrium chamaedrys*	ax1	F 1–2	T 2	N 2			
H	Festucetalia vales.	*Viola rupestris* ssp. *arenaria*	ax1	F 2	T 2	N 1–2			
H	Festucetalia vales.	*Campanula sibirica*	ax1	F 2	T 3–4	N 1–2			
H	Quercetea pubescent.	*Senecio integrifolius*	ax1	F 2–3	T 3	N 2			
H	Quercetea pubescent.	*Hieracium bauhini*	ax1	F 2	T 3	N 2			
H	Festuco-Bromea	*Hypericum perforatum*	ax1	F 2–3	T 0	N 2–3			
H	Festucetalia vag.	*Silene otites* ssp. *pseudotites*	ax1	F 2	T 3	N 2			
Th	Chenopodietea	*Bromus sterilis*	ax1	F 2	T 3	N 4–5			
H	Festuco-Sedetalia	*Poa bulbosa*	ax1	F 1–2	T 3–4	N 1			
H	Festuco-Brometea	*Phleum phleoides*	ax1	F 2	T 3	N 2			
G	Quercetea	*Anthericum ramosum*	ax1	F 2	T 3	N 2			
		Xero-mesophyta:							
N	Quercetea pubesc.	*Cytisus austriacus*	xm3	F 1–2	T 4	N 1			
H	Festucetalia vales.	*Trifolium montanum*	xm3	F 2	T 2	N 1			
H	Festucetalia vales.	*Potentilla arenaria*	xm3	F 1–2	T 3	N 2			
H	Festucion rupicolae	*Astragalus austriacus*	xm3	F 1	T 3	N 1			
H	Festucion rupicolae	*Astragalus asper*	xm3	F 1–2	T 4	N 1			
H	Festucetalia vales.	*Astragalus onobrychis*	xm3	F 1	T 3	N 1			
Th	Festuco-Brometea	*Vicia angustifolia*	xm3	F 0	T 3–4	N 2–3			
TH	Secalietea	*Falcaria vulgaris*	xm3	F 3	T 0	N 0			
TH	Festuco-Brometea	*Seseli annuum*	xm3	F 1–2	T 3	N 2			
H	Festuco-Brometea	*Scabiosa ochroleuca*	xm3	F 1–2	T 3–4	N 1			
H	Festuco-Brometea	*Euphorbia cyparissias*	xm3	F 1–2	T 0	N 0			
H	Festucion rupicolae	*Vinca herbacea*	xm3	F 1–2	T 4	N 1			
H	Festucetalia val.	*Stachys recta*	xm3	F 1–2	T 3	N 2			
Ch	Festucetalia val.	*Veronica prostrata*	xm3	F 2	T 3	N 1–2			
H	Festucetalia val.	*Veronica austriaca* ssp. *austriaca*	xm3	F 2–3	T 3	N 1–2			
H	Festucetalia val.	*Dianthus pontederae*	xm3	F 2	T 4	N 2			
Th	Festuco-Brometea	*Odontites lutea*	xm3	F 2	T 4	N 1–2			
H	Festuco-Bromea	*Hieracium pilosella*	xm3	F 2–3	T 0	N 2			
TH	Festucion vag.	*Thesium arvense*	xm3	F 2	T 3	N 2			

							Subass.: 1	2	3
H	Festuco-Bromea	*Melandrium album*	xm3	F 2–3	T 3	N 2	—	—	···
H	Festuco-Brometea	*Poa angustifolia*	xm3	F 2	T 2	N 3	▬	▬	▬
H	Festuco-Brometea	*Ononis spinosa*	xm2	F 2–3	T 3	N 3	—	···	···
H	Festuco-Brometea	*Medicago falvata*	xm2	F 1–2	T 3	N 2	···	···	···
TH	Festuco-Brometea	*Medicago lupulina*	xm2	F 2–4	T 3	N 2	···	···	···
H	Festuco-Brometea	*Coronilla varia*	xm2	F 1–2	T 3	N 1–2		···	—
H	Festuco-Brometea	*Pimpinella saxifraga*	xm2	F 0	T 0	N 2–3		···	···
TH	Onopordion	*Cynoglossum officinale*	xm2	F 1–2	T 2	N 3	···		···
H	Festuco-Brometea	*Salvia pratensis*	xm2	F 2	T 2	N 2		···	···
Th	Festuco-Brometea	*Thlaspi perfoliatum*	xm2	F 3	T 3–4	N 2		···	···
H	Festuco-Brometea	*Achillea millefolium* ssp.						···	···
.		*collina*	xm2	F 2	T 4	N 2		···	···
H	Festucetalia val.	*Achillea pannonica*	xm2	F 2	T 4	N 2			···
H	Festucetalia val.	*Scorzonera purpurea*	xm2	F 2	T 4	N 2			···
H	Quercetea pubesc.	*Leontodon hispidus*	xm2	F 0	T 2	N 2–3			
H	Festuco-Brometea	*Taraxacum laevigatum*	xm2	F 1–2	T 3	N 2		···	
G	Festuco-Brometea	*Muscari racemosum*	xm2	F 2	T 4	N 2		···	
G	Festuco-Brometea	*Asparagus officinalis*	xm2	F 2	T 3	N 2–3			···
G	Festucetalia vag.	*Iris. humilis* v. *arenaria*	xm2	F 2	T 3	N 1–2		···	
H	Quercetea pubesc.	*Inula salicina* v. *denticulata*	xm2	F 2–3	T 3	N 2			···
H	Festuco-Brometea	*Galium verum*	xm1	F 0	T 2–3	N 1–2	···	—	—
H	Festucetalia val.	*Knautia arvenis*	xm1	F 2–3	T 2–3	N 0		—	···
Th	Secalietea	*Viola arvensis*	xm1	F 2–3	T 0	N 2–3	···	···	
Th	Chenopodietea	*Senecio vernalis*	xm1	F 2–3	T 3–4	N 3		···	···
H	Festuco-Puccinell.	*Scorzonera cana*	xm1	F 2–4	T 4	N 1–2		···	···
H	Festuco-Bromea	*Silene vulgaris*	xm1	F 2–3	T 3	N 2		···	—
G	Festucion rupic.	*Gagea pusilla*	xm1	F 2	T 4	N 2	···	···	
G	Festuco- Brometea	*Ornithogalum umbellatum*	xm1	F 2–3	T 4	N 3		···	···
G	Querco-Fagea	*Epipactis athrorubens*	xm1	F 2–4	T 3	N 2			···
H	Festuco-Bromea	*Dactylis glomerata*	xm1	F 0	T 2–3	N 0			···
		Mesophyta:							
H	Molinio-Arrhenath.	*Trifolium pratense*	m3	F 0	T 0	N 2–3		···	···
Th	Chenopodietea	*Senecio vulgaris*	m3	F 3	T 0	N 3–4		···	
TH	Arrhenatheretea	*Tragopogon orientalis*	m3	F 2–3	T 2–3	N 2–3			···
H	Molinio-Arrhenath.	*Taraxacum officinalis*	m3	F 2–3	T 0	N 2–3		···	
H	Arrhenatheretea	*Ranunculus acris*	m2	F 0	T 0	N 2–3		—	—
H	Molinio-Arrhenath.	*Trifolium repens*	m2	F 0	T 0	N 2–3		···	···
H	Molinio-Arrhenath.	*Lotus corniculatus*	m2	F 0	T 0	N 2–3		···	···
H	Quercetea	*Lithospermum officinale*	m2	F 2	T 2	N 3			···
Th	Chenopodio-Scler.	*Bilderdykia convolvus*	m2	F 0	T 3	N 3			···
G	Quercetea	*Cephalanthera rurra*	m2	F 3	T 3–4	N 2–3		···	···
Ch	Festucetalia vales.	*Genista tinctoria* ssp. *elatior*	m1	F 0	T 3	N 1–2		···	···
Th	Arction	*Anthriscus caucalis*	m1	F 3	T 3	N 3–4			···
		Meso-hygrophyta:							
H	Querciom pubesc.	*Thalictrum simplex* ssp.							
		galioides	mhg3	F 3–4	T 3–4	N 2		—	···
H	Molinio-Arrhenath.	*Polygala comosa*	mhg3	F 0	T 3	N 1		—	···
Ch	Populetalia	*Solanum dulcamara*	mhg3	F 4–5	T 3	N 3			···
G	Quercetea pubesc.	*Carex flacca* ssp. *cuspidata*	mhg3	F 0	T 3	N 2			···
H	Molinio-Arrhenath.	*Agrostis stolonifera* ssp.							
		gigantea	mhg1	F 3	T 0	N 2–3			···

stratum is also becoming richer. Besides *Crataegus monogyna* and *Berberis vulgaris*, *Ligustrum vulgare* and *Cornus sanguinea* which may be regarded as relict species of ancient oak forests occur here as well as in the west part of the region between the Danube and the Tisza (KOVÁCS-LÁNG and SZABÓ, 1971). In its herb stratum, apart from *Festuca rupicola, Asperula cynanchica* has spred particularly.

F. (Qu)–P.a. salicetosum rosmarinifoliae (n.s.ass)

(Syn.: *Festuco-Quercetum* populetosum albae mesophilum BODRK. 57).

It is found in those spaces among the sand-hills of Emlékerdő, where organic matter-rich humus occurs at about 80 cm depth below the superficial layer. This formed once the surface soil of the ancient oak forests (BODROGKÖZY, 1957). The most beautiful poplar forests of the nature conservation area occur there.

Hydroecological conditions

For the closing of the upper tree stratum, atmospheric precipitation is stored mainly in the near-surface layers, remaining there throughout the whole summer season. Detailed data are presented in Fig. 17.

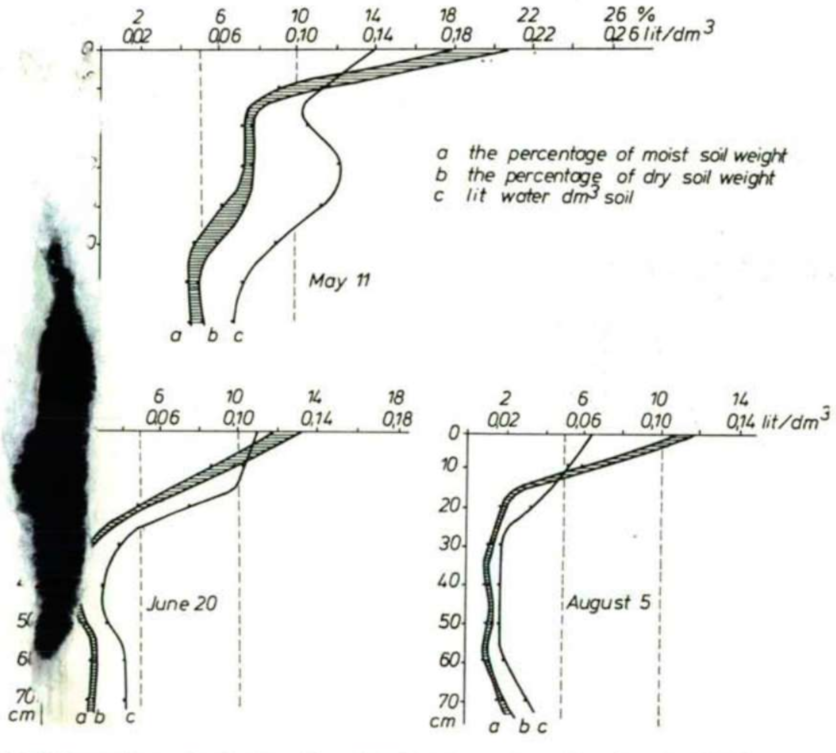

Fig. 14. Moisture dynamics in the soil profile of white poplar gallery forest of *Calamagrostis* type.

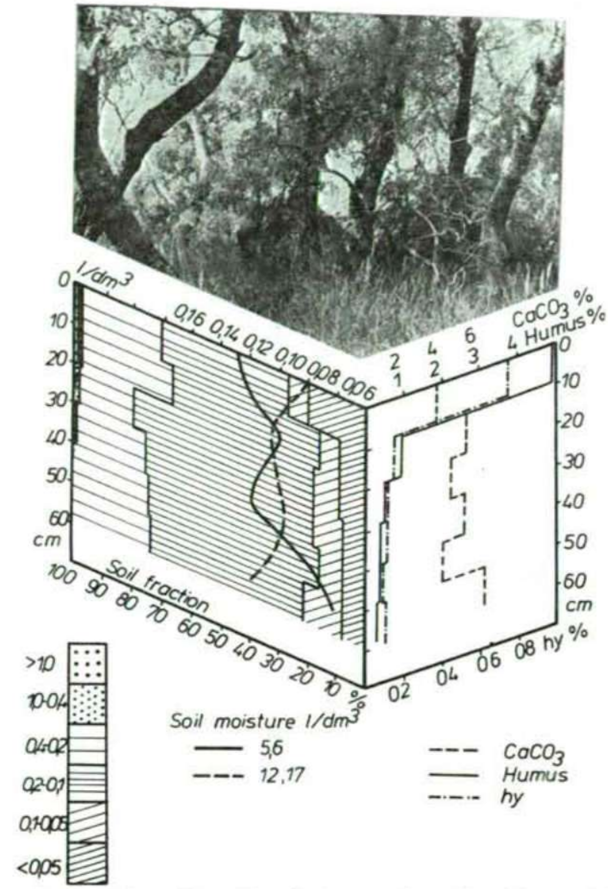

Fig. 15. Analytical data on the soil profile of whte poplar gallery forest of *Calamagrostis* type.

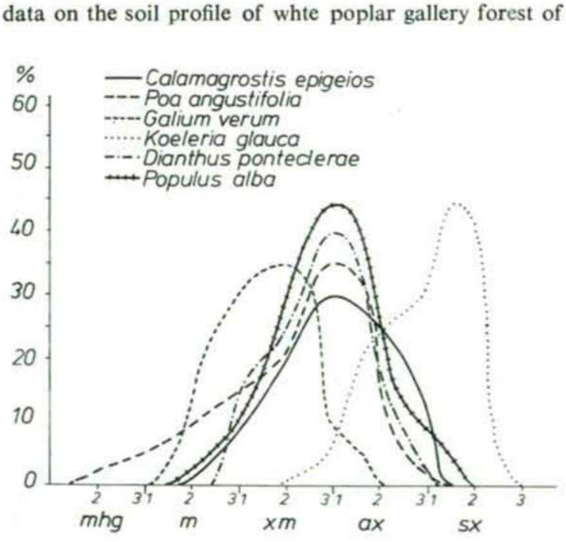

Fig. 16. Hydroecological graphs for the character species of *Festuco (Querco) — Populetum albae* calamagrostetosum.

Cenotical conditions

Changes occurred in the shrub stratum with the growth of *Salix repens* ssp. *rosmarinifolia*. Otherwise, it is like the stands of the type in respect of the number of species and the contribution to cover. The steno-xerophytes do not occur any more in its herb stratum, and the members of astenoxerophytes have also diminished. In the last decades, ax3 *Calamagrostis epigeios* has also increased to the expense of *Festuca rupicola*. The differential species of this subassociation are the *Campanula sibirica, Teucrium chamaedrys* (both ax1).

Members of xeromesophytes dominate in respect of species number, particularly the type xm3 and xm2 species. Nevertheless, their contributions to cover is little, with the exception of *Poa angustifolia*. Further details are presented in Table 3.

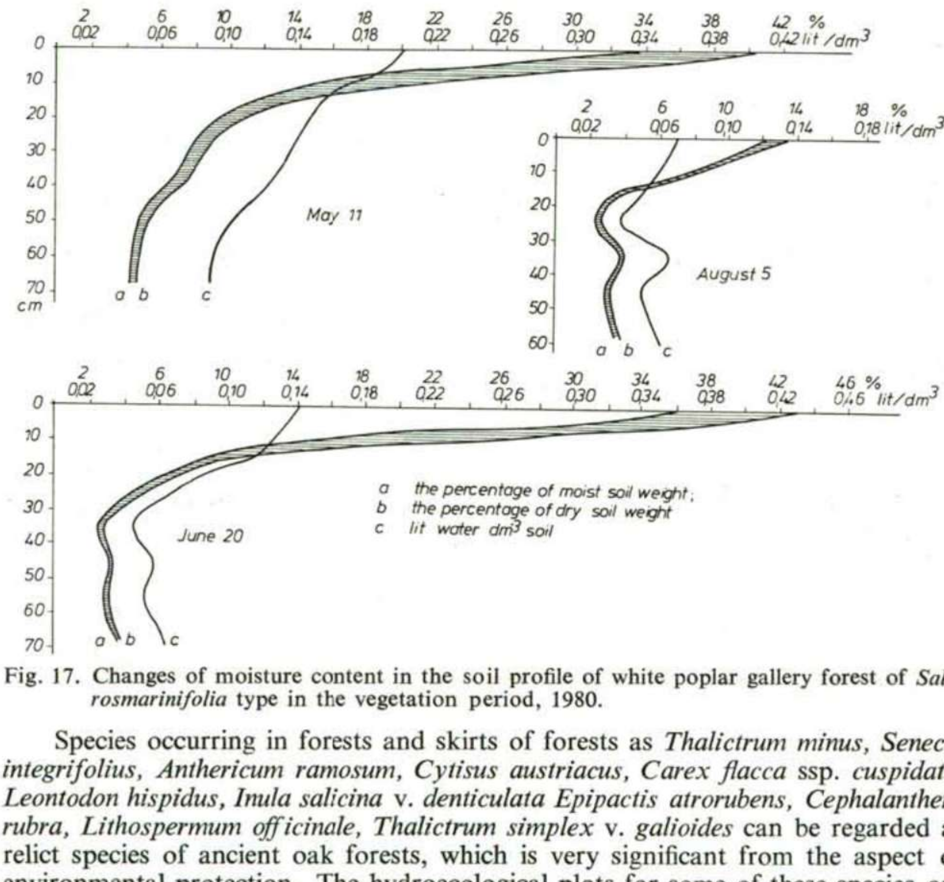

Fig. 17. Changes of moisture content in the soil profile of white poplar gallery forest of *Salix rosmarinifolia* type in the vegetation period, 1980.

Species occurring in forests and skirts of forests as *Thalictrum minus, Senecio integrifolius, Anthericum ramosum, Cytisus austriacus, Carex flacca* ssp. *cuspidata, Leontodon hispidus, Inula salicina* v. *denticulata Epipactis atrorubens, Cephalanthera rubra, Lithospermum officinale, Thalictrum simplex* v. *galioides* can be regarded as relict species of ancient oak forests, which is very significant from the aspect of environmental protection. The hydroecological plots for some of these species are presented in Figs 17 and 18.

The total contributions of species belonging to the single categories and subgroups of these categories to cover as well as the number of these species are seen in Figs. 19 and 20. The differences among the three subassociations are also apparent from these graphs.

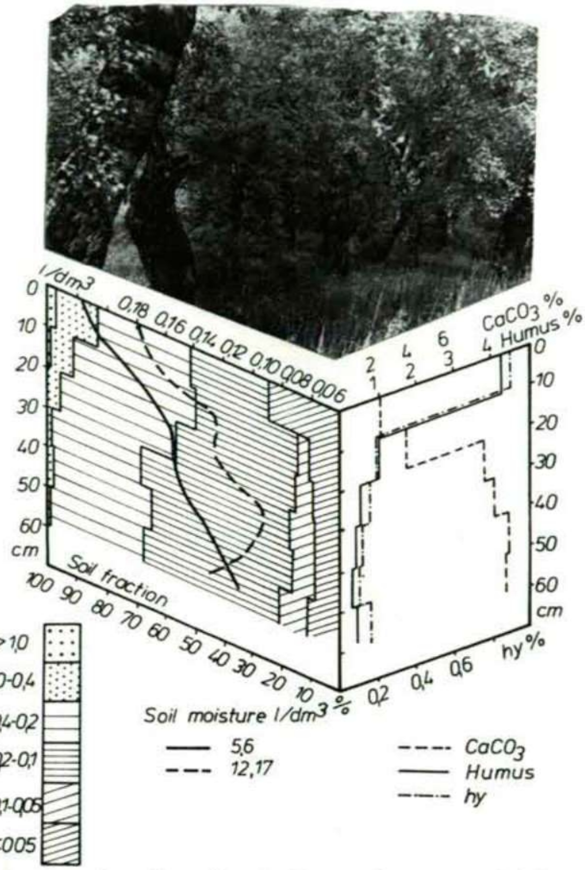

Fig. 18. Analytical data on the soil profile of white poplar grove of *Salix rosmarinifolia* type among sand hills in 1980.

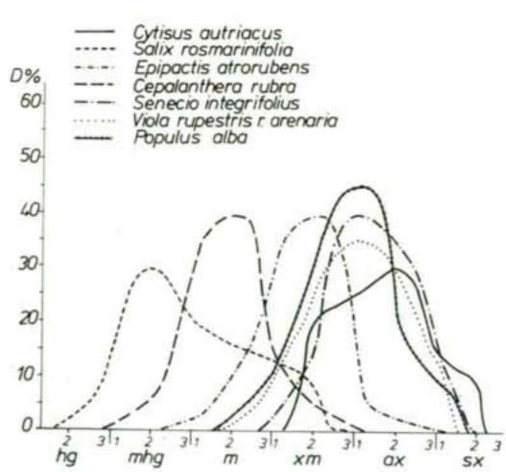

Fig. 19. Hydroecological graphs of the species of the *Salix rosmarinifolia* subassociation.

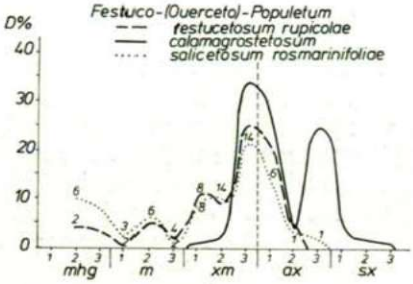

Fig. 20. Distribution of species of the single subunits of association according to their contributions to coverage, with special regard to the subgroups of categories (1–3) with the indication of species number.

Changes in phytomass production

The effect of ecological conditions on the phytocenoses is also evidenced by the seasonal changes of organic matter production. PRÉCSÉNYI (1967) and ZÓLYOMI and PRÉCSÉNYI (1970) dealt with the methodology of these studies. — Investigations of this kind in connection with the lichen cenology of sandy forest-steppe plant communities were performed by VERSEGHY and KOVÁCS-LÁNG (1974): Studies on grass cenoses were reported by KOVÁCS-LÁNG and SZABÓ (1971) as well as SIMON and BATANOUNY (1971), SIMON and KOVÁCS-LÁNG (1972).

PRÉCSÉNYI and OPAUSZKI (1979) investigated the concentrations of micro- and ultraelements, and HORÁNSZKY et al. (1980) performed morphological studies on the populations of *Festuca vaginata.*

Table 4. Changes in organic matter production of sand steppe plant communities in the vernal and aestival spects (1 = May, 2 = June).

		Grasses and sedges	Dicotyledones	Living matter	Dead matter	Sub-surface total production
				Total (g/m²)		
Festucetum vaginatae	1	38.64	26.60	65.24	253.32	318.56
stipetosum bor.	2	55.20	25.88	81.08	250.00	331.08
Festuco rupicolae	1	42.96	101.32	144.28	482.64	626.92
salicetosum rosm.	2	113.52	153.14	266.66	258.92	525.58
Fest. rup.	1	73.32	46.64	119.96	405.32	525.28
Filipendula fac.	2	149.16	163.00	312.16	206.10	518.26
Fest. rup. molinietosum	1	82.64	22.60	105.24	512.00	617.24
Stipa capillata fac.	2	194.40	82.20	276.60	299.60	576.20
Festuco (Querco) — Populetum calamag-	1	59.96	10.64	70.60	320.00	390.60
rostetosum	2	251.20	62.56	313.76	111.40	425.16
Fest. (Qu.)-Pop.	1	116.00	22.00	138.00	262.00	400.00
salicetosum rosm.	2	194.40	82.00	276.40	299.60	576.00

Further supplementary studies were also performed in connection with the phytomass production of the aestival aspect of plant communities in the sandy forest-steppe of Emlékerdő at Ásotthalom. Their comparative data are presented in Table 4.

***

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